Chapter1. Rotational Dynamics

MCQ's (1 Mark Each)

1. A diver in a swimming pool bends his head before diving. It
   a) Increases his linear velocity
   b) Decreases his angular velocity
   c) Increases his moment of inertia
   d) Decreases his moment of inertia

   Ans: d) Decreases his moment of inertia

2. The angular momentum of a system of particles is conserved
   a) When no external force acts upon the system
   b) When no external torque acts upon the system
   c) When no external impulse acts upon the system
   d) When axis of rotation remains the same

   Ans: b) When no external torque acts upon the system

3. A stone is tied to one end of a string. Holding the other end, the string is whirled in a horizontal plane with progressively increasing speed. It breaks at some speed because
   a) Gravitational forces of the earth is greater than the tension in string
   b) The required centripetal force is greater than the tension sustained by the string
   c) The required centripetal force is lesser than the tension in the string
   d) The centripetal force is greater than the weight of the stone

   Ans: b) The required centripetal force is greater than the tension sustained by the string

4. The moment of inertia of a circular loop of radius R, at a distance of R/2 around a rotating axis parallel to horizontal diameter of the loop is
   a) $\frac{1}{2}MR^2$
   b) $\frac{3}{4}MR^2$
   c) MR^2
   d) $2MR^2$

   Ans: b) $\frac{3}{4}MR^2$

5. A 500 kg car takes a round turn of radius 50m with a velocity of 36 km/hr. The centripetal force is
   a) 250N
   b) 750N
   c) 1000N
   d) 1200N
   Ans: c) 1000N

6. A cyclist riding a bicycle at a speed of $14\sqrt{3}$ m/s takes a turn around a circular road of radius $20\sqrt{3}$ m without skidding. Given g = 9.8 m/s², what is his inclination to the vertical
   a) 30^0
   b) 45^0
   c) 60^0
   d) 90^0
   Ans: c) 60^0

7. A string of length ℓ fixed at one end carries a mass m at the other. The string makes $2/\pi$ revolutions/sec around the vertical axis through the fixed end. The tension in the string is
   a) 2 ml
   b) 4 ml
   c) 8 ml
   d) 16 ml
   Ans: d) 16 ml

Very Short Answer (VSA) (1 MARK Each)

1. Find the radius of gyration of a uniform disc about an axis perpendicular to its plane and passing through its center.
2. Does the angle of banking depend on the mass of the vehicle?
3. During ice ballet, while in the outer rounds, why do the dancers outstretch their arms and legs.
4. State the principle of conservation of angular momentum.
5. Two bodies have their moments of inertia I and 2I respectively about their axis of rotation. If their kinetic energies of rotation are equal, then what is the ratio of their angular velocity.

6. What is meant by well of death?

7. State the equation for kinetic energy of rolling motion.

8. A hollow sphere has radius 6.4 m. what is the minimum velocity required by a motor cyclist at bottom to complete the circle.   (Ans: V=17.7 m/s)

9. A bend in a level road has a radius of 100m. find the maximum speed which a car turning this bend may have without skidding, if the coefficient of friction between the tyres and road is 0.8. (Ans: V_{max}= 28 m/s)

Short Answer I (SA1) (2 MARKS Each)

1. A flywheel is revolving with a constant angular velocity. A chip of its rim breaks and flies away. What will be the effect on its angular velocity?

2. The moment of inertia of a uniform circular disc about a tangent in its own plane is $5/4MR^2$ where M is the mass and R is the radius of the disc. Find its moment of inertia about an axis through its centre and perpendicular to its plane.

3. Derive an expression for maximum safety speed with which a vehicle should move along a curved horizontal road. State the significance of it.

4. Obtain an expression for Total kinetic energy in terms of radius of gyration of the body.

5. The moment of inertia of a body about a given axis is 1.2 kgm^2 . initially the body is at rest. For what duration on angular acceleration of 25 radian/sec^2 must be applied about that axis in order to produce a rotational kinetic energy of 1500 joule? *(Ans: t=2sec)*

6. A bucket containing water is tied to one end of a rope 5 m long and it is rotated in a vertical circle about the other end. Find the number of rotations per minute in order that the water in the bucket may not spill. *(Ans: n=13.37 rpm)*

7. A body weighing 0.5 kg tied to a string is projected with a velocity of 10 m/s. The body starts whirling in a vertical circle. If the radius of the circle is 0.8 m, find the tension in the string when the body is at the top of the circle. *(Ans: T= 3.8 N)*

Short Answer II (SA2) (3 MARKS Each)

1) Derive an expression for kinetic energy of a rotating body with uniform angular velocity.

2) Obtain an expression for the torque acting on a rotating body with constant angular acceleration.

3) Derive an expression for the difference in tensions at highest and lowest point for a particle performing vertical circular motion.

4) Obtain an expression for the angular momentum of a body rotating with uniform angular velocity.

5) A railway track goes around a curve having a radius of curvature of 1 km. The distance between the rails is 1 m. Find the elevation of the outer rail above the inner rail so that there is no side pressure against the rails when a train goes round the curve at 36 km / hr. *(Ans: h = 1.02 cm)*

6) A flywheel of mass 8 kg and radius 10 cm rotating with a uniform angular speed of 5 rad / sec about its axis of rotation, is subjected to an accelerating torque of 0.01 Nm for 10 seconds. Calculate the change in its angular momentum and change in its kinetic energy. *(Ans.: 0.1kgm^2/s, 0.625 J)*

7) Two wheels of moment of inertia 4 kgm^2 rotate side by side at the rate of 120 rev / min and 240 rev / min respectively in the opposite directions. If now both the wheels are coupled by means of a weightless shaft so that both the wheels rotate with a common angular speed. Calculate the new speed of rotation. (Ans: n = 60 rpm)

Long Answer (LA) (4 marks Each)

1) State and explain the theorem of parallel axes.

2) What is a conical pendulum? Obtain an expression for its time period.

3) Obtain an expression for maximum safety speed with which a vehicle can be safely driven along a curved banked road.

OR

Show that the angle of banking is independent of mass of vehicle.